

Hall B Status



CLAS Collaboration Meeting
June 20 - 22, 2004

Volker D. Burkert
Jefferson Lab

Run status
Publication status/analysis
Status of new projects
G10/G11 runs
2004/2005 tentative run schedule
DOE Science & Technology Review
Comments on pentaquarks
12 GeV Upgrade



Thomas Jefferson National Accelerator Facility



Office of
Science

Hall B Status Overview

- 22 major CLAS production runs completed
 - e1a/b, g1a/b, g6a, e1c, e2a, g6b, g2a, g1c, g3, e1d, e5, eg1b, g8a, g6c, e1-6, e6, e2b, g7, e1e, e1f/g, [eg2](#), [g10](#) (+2 non-CLAS experiments: g5, rad- ϕ)
- Publications
 - 16 technical papers published
 - 27 physics papers published/accepted in PRL, PRC, PRD (+2 CLAS related papers)
 - 3 submitted (+ 2 CLAS related papers)
 - 5 in collaboration review
- Projects preparation for approved experiments
 - [PrimEx \(\$\pi^0\$ lifetime measurement\)](#)
 - DAQ Upgrade to 10KHz rate
 - Deeply Virtual Compton Scattering (Accessing GPDs) => [Michel Garcon](#)
 - [BoNus Experiment \(Neutron structure function\)](#)
 - [Frozen Spin Target \(search for missing \$N^*\$'s\)](#)
 - New Cerenkov counter for one CLAS sector (for small Q^2 GDH)
 - Polarimeter for linearly polarized photons (g8)
 - Start counter for G12 experiment
 - CLAS Physics Data Base => [V. Sapunenko](#)
- Energy calibration of the photon tagging system
- Prototyping effort for 12 GeV Upgrade – W-SciFi EC, SVT, [ToF](#)



Technical Publications

- Torus Magnet IEEE Mag.25 (1989) 1902
- Drift Chambers
 - construction Mac Mestayer NIM A323 (1992) 191
 - update Mac Mestayer NIM A367 (1995) 316
 - Region I Dan Carman NIM A419 (1998) 315
 - Region II L.M. Qin NIM A411 (1998) 265
 - Summary Dan Carman NIM A449 (2000) 81
- Cerenkov Counter Paul Stoler NIM A465 (2001) 414
- TOF Counters Elton Smith NIM 432 (1999) 265
- Start Counters Simon Taylor NIM A462 (2001) 484
- Forward Cal. Cole Smith NIM A460 (2001) 239
- Large Angle Cal. Mauro Taiuti NIM A447 (2000) 431
 - Response Mauro Taiuti NIM accepted (2004)
- Tagging System
 - window Jim O'Brien NIM 421 (1999)
 - tagger Jim O'Brien NIM 440/2 (2000) 263
- Polarized target Chris Keith NIM A501 (2003) 327
- CLAS Overview Bernhard Mecking NIM A503 (2003) 513



Hall B Physics Publications (PRL/PRC/PRD)

- 27 - published
- 3 - submitted
- 5 - in collaboration review

❖ Publications based on CLAS data.

- ❖ 2 - published
- ❖ 2 - submitted

Hadron Structure & Spectroscopy

- η -Electroproduction in the S11(1535) region, PRL86 (2001) 1702
- Double Spin Asymmetry in $ep \rightarrow e\pi^+n$, PRL88 (2002) 082001
- $N \rightarrow \Delta(1232)$ Multipoles from p^0 Electroproduction, PRL88 (2002) 122001
- ❖ QED Radiative Corrections in Exclusive Pion Electroproduction PRD66 (2002) 074004
- η -Photoproduction on the Proton, PRL89, (2002) 222002-1
- Polarisation transfer in $ep \rightarrow eK^+\Lambda$, PRL90,131804 (2003),
- ❖ Single Quark Transition Analysis of N^* Excitations in $[70,1^-]$, PRC67, 035204 (2003)
- $ep \rightarrow e\pi^+\pi^-$ and baryon resonance analysis, PRL91, 022002-1(2003)
- First measurement of beam-target spin asymmetry in $ep \rightarrow epp^0$, PRC 68, 035202
- Measurement of $\sigma_{LT'}$ in the $\Delta(1232)$ region PRC {bf 68}, 032201 (2003)
- Evidence for an Exotic Baryon State with $S=+1$, on Deuterium PRL 91, 252001 (2003)
- Photoproduction of $K^+\Lambda/\Sigma$, PRC RC, accepted nucl-ex/0305028 (2003)
- Electroproduction of $ep \rightarrow e\pi^+$ in the first and second resonance region, CLAS review
- Single Spin Asymmetry in $ep \rightarrow e\pi^+n$, in the $\Delta(1232)$ region, CLAS review.
- Photoproduction of cascades from proton targets
- Evidence for $\Theta^+(1540)$ excitation on protons, PRL 92, 0322001 (2004).
- First Observation of Exotic Mesons in Photoproduction



Hall B Physics Publications – cont'd

Structure Functions & Hard Processes

- Inclusive spin structure function in $eD \rightarrow eX$, PRC67, 055204 (2003)
- F2 and Moment analysis in $ep \rightarrow eX$, PRD 67 (2003)
- Inclusive double polarisation asymmetry, g_1 , G_{1p} , PRL 91, 222002.
- ϕ -Photoproduction at large t , PRL85 (2000) 4682
- ϕ -Electroproduction, PRC63 (2001) 065205-1
- $K^+\Lambda(1520)$ Electroproduction, PRC63 (2001) 044601
- ρ^0 -Photoproduction, PRL87 (2001) 172002
- Beam Asymmetry in DVCS PRL87 (2001) 182002
- Photoproduction of ω mesons at high t , PRL90, 022002-1 (2003)
- Beam Single Spin Asymmetry in $ep \rightarrow e\pi^+X$ in the DIS kinematics, PRD submitted, nucl-ex/0301012
- Deeply exclusive ρ^0 production, CLAS review
- Tensor Polarization of the ϕ meson photo-produced at high t , PRC 69, 032203(R) (2004).
- ❖ Twist analysis of $\Gamma_{1p}(Q^2)$, PRL subm.
- ❖ Bjorken Integral $\Gamma_1(p-n)$ from inclusive polarized structure functions g_{1p} , g_{1n}

Nuclear Processes

- Photofission of Heavy Nuclei, PRL84 (2000) 5740
- Photofission of Heavy Nuclei, PRC65, 044622 (2002)
- Nuclear Scaling in $A(e,e')$ at $x>1$, PRC 68, 014313 (2003)
- Two-Nucleon Momentum Distributions in $^3\text{He}(e,e'pp)n$, PRL 92, 52303 (2004).
- Deuteron Photo-disintegration, PRC accepted
- Deuteron Photo-disintegration PRL, submitted.
- Proton source size in $eA \rightarrow eppX$, PRL submitted
- Survey of beam asymmetries in semi-inclusive scattering on ^4He or ^{12}C .



Hall B Publication Overview (refereed Journals only)

	Spectroscopy & Structure	Hard scattering & Structure F.	Nuclear processes	Sum
2000	-	1	1	2
2001	1	4	-	5
2002	4	-	1	5
2003	4	4	2	10
2004	2 + 3	2 + 1	1 + 3	4 + 3 + 4
Sum	11 + 3	11 + 1	5 + 3	27 + 3 + 4

Published/accepted submitted in CLAS review

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Physics Impact of CLAS Data I

Paper

Physics

#citations (>20)

06/18/04

■ PRL 85 (2000) 4682	ϕ -Photoproduction at high t	35	
■ PRL 86 (2001) 1702	Study of $S_{11}(1535)$ in η electroproduction	27	
■ PRL 87 (2001) 182002	Deeply Virtual Compton Scattering	96	CAA
■ PRL 88 (2002) 182002	Multipoles in the $\gamma^*N\Delta(1232)$ transition	31	
■ PRL 91 (2003) 252001	Evidence for an Exotic Baryon State with $S=+1$ on deuterium	215	CAA
■ PRL 92 (2004) 32001	Evidence for an exotic Baryon with $S=+1$ on Protons	89	CAA



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Physics Impact of CLAS Data II

Paper	Physics	#spires citations per month > 0.7
■ PRD 67 (2003) 092001	Kinematically complete measurement of F2	0.8 CAA
■ PRL 87 (2001) 182002	Deeply Virtual Compton Scattering	2.6 CAA
■ PRL 88 (2002) 182002	Multipoles from $\gamma^* N \Delta(1232)$ transition	1.1
■ PRD (2004)	SSA in $\vec{\text{SIDIS}} \vec{e}p \rightarrow e\pi^+X$	1.2 CAA
■ PRL 91 (2003) 252001	Evidence for exotic baryon on deuterium	18.5 CAA
■ PRL 92 (2004) 032001	Evidence for exotic baryon on protons	13 $\overline{\text{CAA}}$



Summary of Events since last CLAS Meeting

- EG2 run ~2/3 completed (quark propagation, color transparency)
- Completed G10 run May 15, Θ^+ search on deuterium
 - tagger energy calibration
- Short test run in preparation of EG3 (Ξ_5 search), data rates, DAQ performance.
- Started G11 run – May 22

- April 1, 2004, Signing of CD0 for the 12 GeV Upgrade
 - Begin preparations for Conceptual Design Report
 - Update of Physics Case for CLAS⁺⁺ => talk by Latifa Elouadrhiri
 - Develop experimental equipment => talk by Will Brooks
 - Need to fully involve users in this effort

- EBAC Proposal to DOE receives good reviews

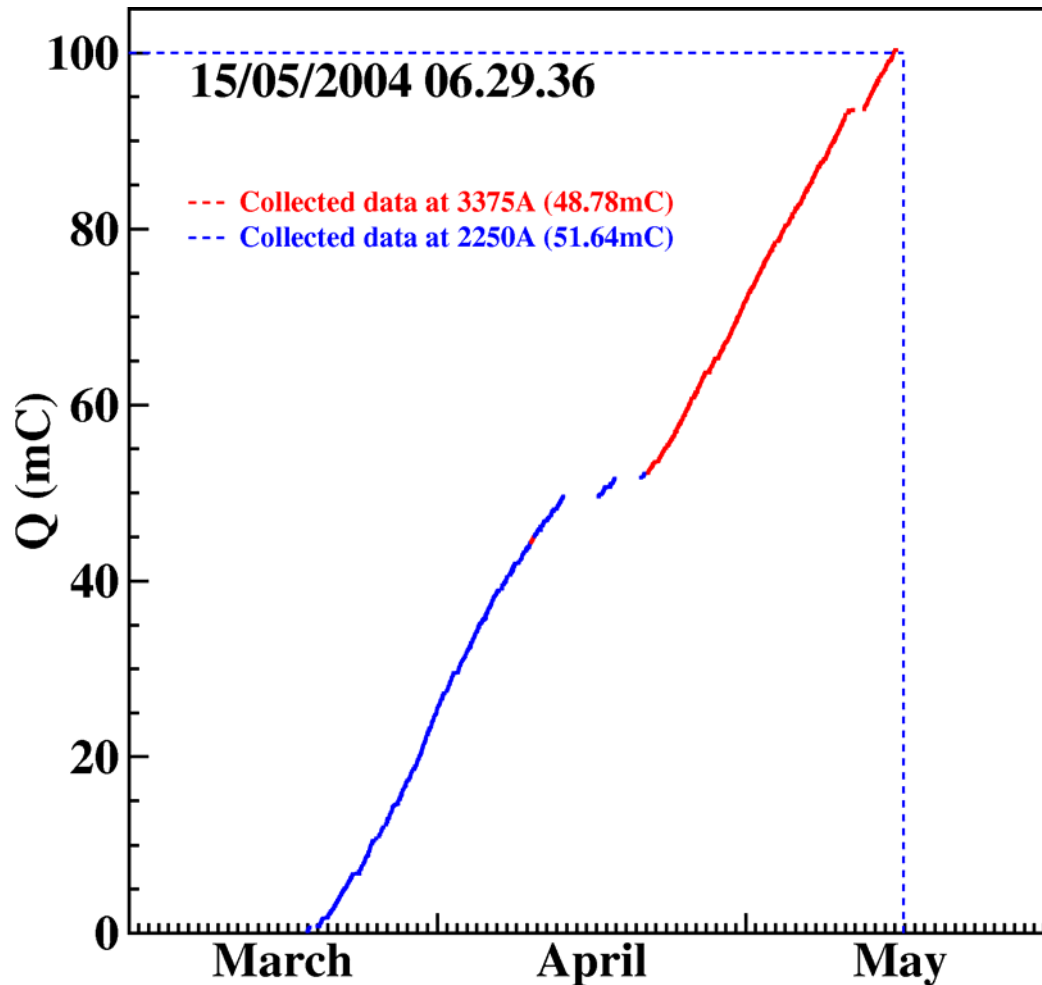
- June 14-16, Science & Technology DOE review
 - Experimental and theoretical science truly outstanding,
 - Impact goes much beyond the nuclear physics community (pentaquark,..)
 - LQCD, World Center of Excellence for Hadron Physics, and Exited Baryon Analysis Center (EBAC) seen as important initiatives.



G10 Run - Acquired Data

- Data with CLAS torus at **2250A**:
 1. 4710M production triggers on LD2 (51.6mC of integrated electron beam charge).
 2. 133M calibration triggers on LH2 (2.9mC).
- Data with CLAS torus at **3375A**:
 1. 5000M production triggers on LD2 (48.78mC of integrated electron beam charge).
 2. 267M calibration triggers on LH2 (4.5mC).
- Tagger energy calibration - using PrimEx pair spectrometer with microstrip detectors.
- Tagger normalization runs.

G10 - Accumulated production data:



G10 - Analysis efforts

□ Analysis teams – G10:

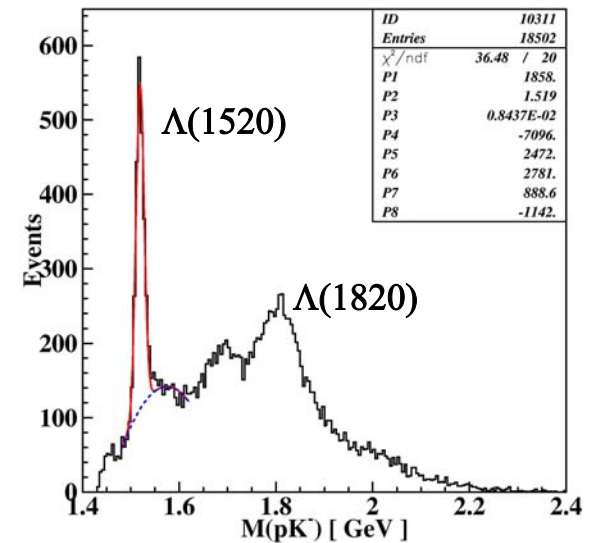
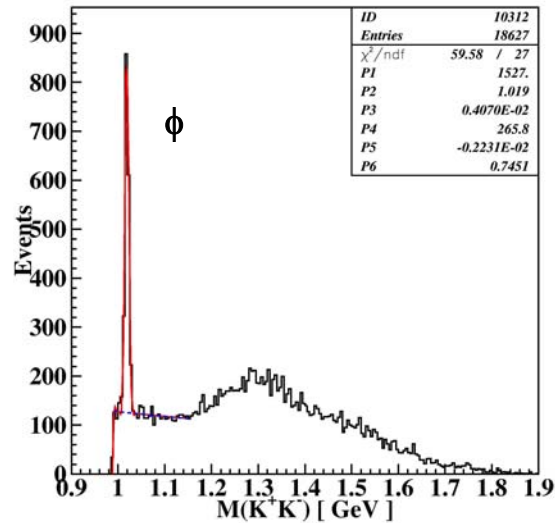
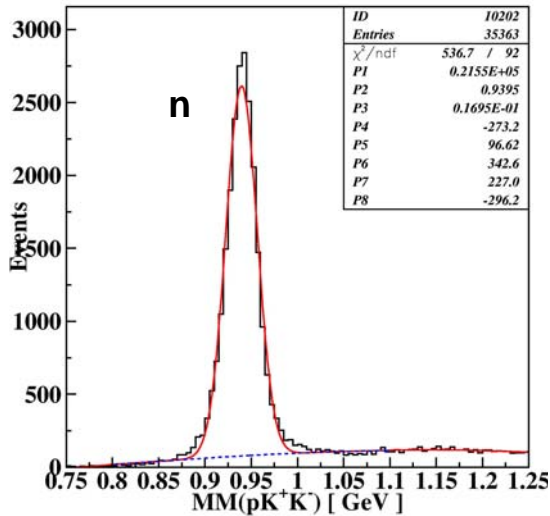
- o Dan Carman (Ohio), Reinhard Schumacher (Carnegie Mellon)
- o Dave Tedeschi, Nathan Baltzell (USC)
- o Ken Livingston, Bryan McKinnon (Glasgow)
- o Michel Guidal, Silvia Niccolai (ORSAY)
- o Patrizia Rossi, Marco Mirazita (INFN, Frascati)
- o Eugene Pasyuk (Arizona), Luminita Todor (Richmond, Jlab)
- o Ken Hicks (Ohio), Stepan Stepanyan (JLab)

Common rules for all pentaquark analyses:

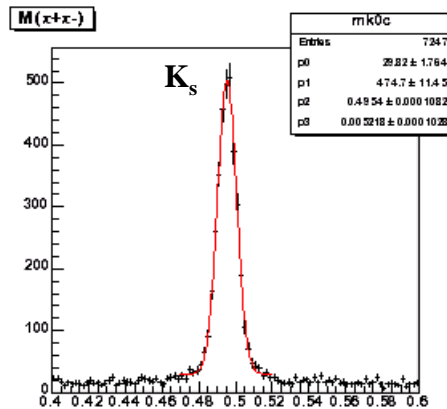
1. Fully calibrated detector system
2. Use only pre-selected “golden runs” (fully functioning equipment)
3. Analysis in well defined CLAS fiducial volume
4. Energy and momentum corrections that use independent well-studied channels
5. Analysis without and with kinematical constraints whenever possible
6. Independent analyses by several groups
7. Use independent data sets for optimization of cuts and for analyses
8.

CLAS - G10 “online” plots

Fully exclusive processes: $\gamma d \rightarrow K^- p K^+ n$

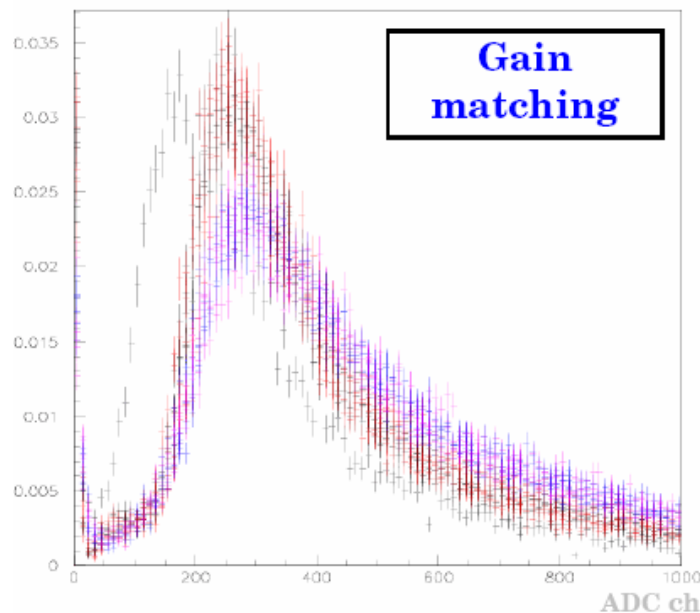
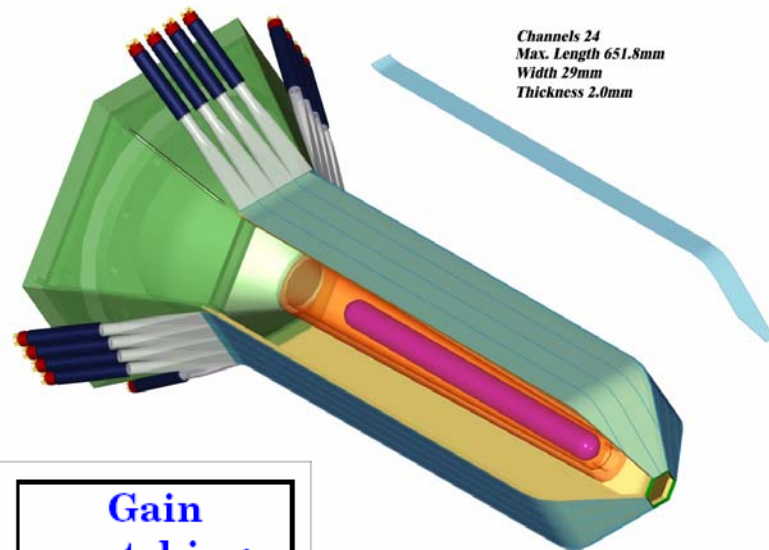


$\gamma d \rightarrow K^- p K_s(\pi^+ \pi^-) p_{sp}$



Start Counter for Tagged Photon Experiments

- Needed in tagged photon experiments for improved triggering and particle identification capabilities
- First stage with 24 azimuthal strips designed, constructed, commissioned in record time. Now used in G11 run.

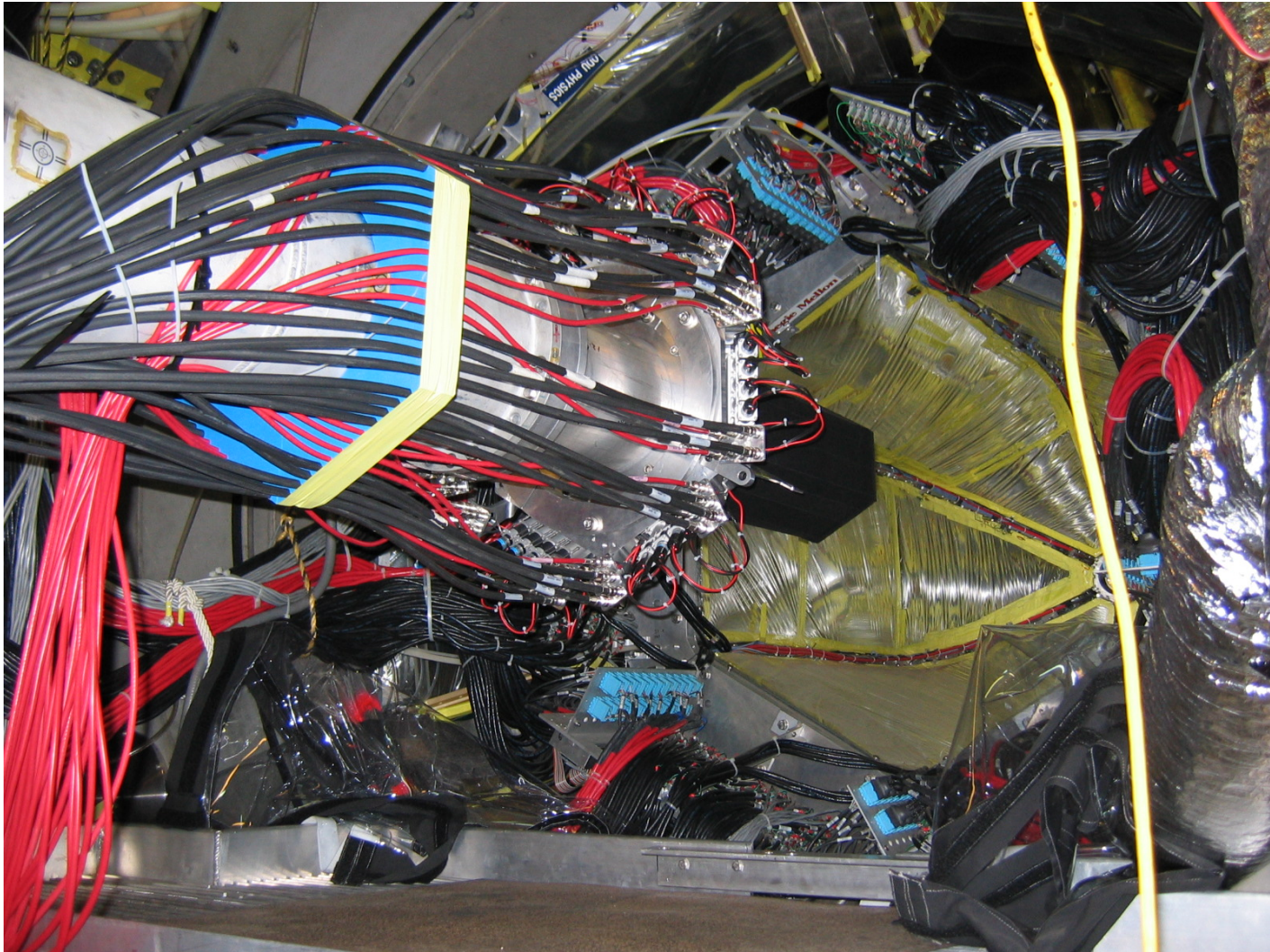


CLAS Start Counter - fully assembled



CLAS

Start Counter installation



CLAS - G11 “online” plots

Calibration team:

L.Elouadrihri (JLab) and R. DeVita (INFN) as supervisors

M.Ungaro (U.Conn) as 'chef'

L.Guo (JLab): TAGGER/Start Counter

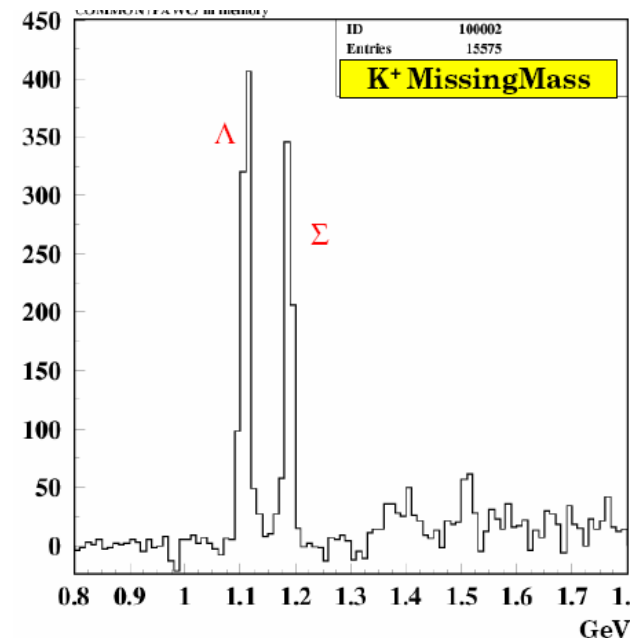
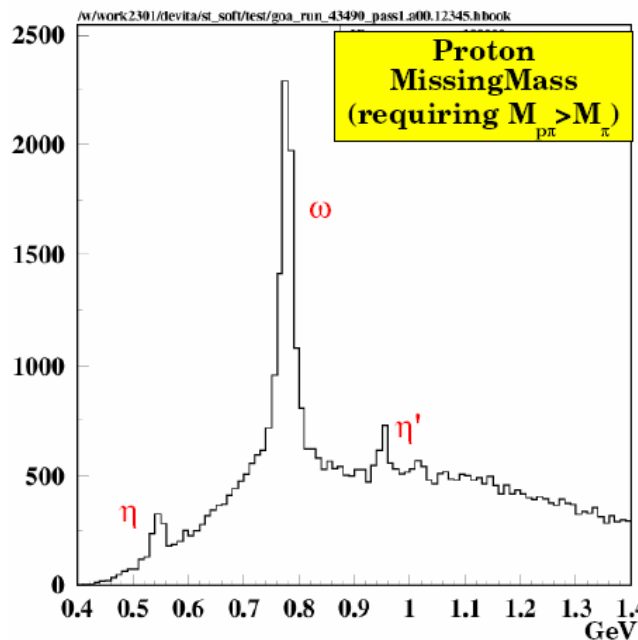
J. Goett(RPI): DC calibration

N. Baltzell (SCU): TOF calibration

D.Dale (KU), E.Pasyuk (ASU): Normalization

M.Ostrick (JLab): EC timing calibration

C.Smith (UVA): EC energy calibration

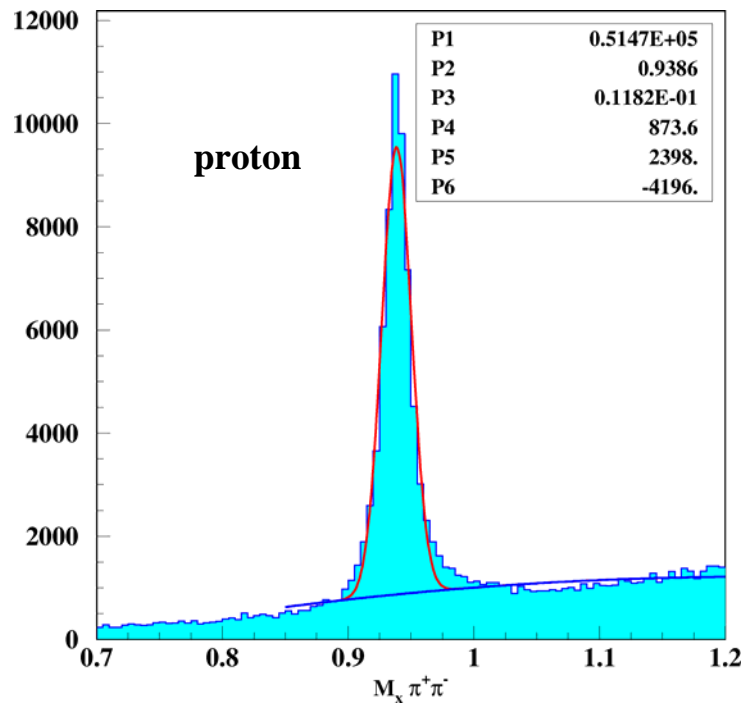


CLAS - G11 “online” plots

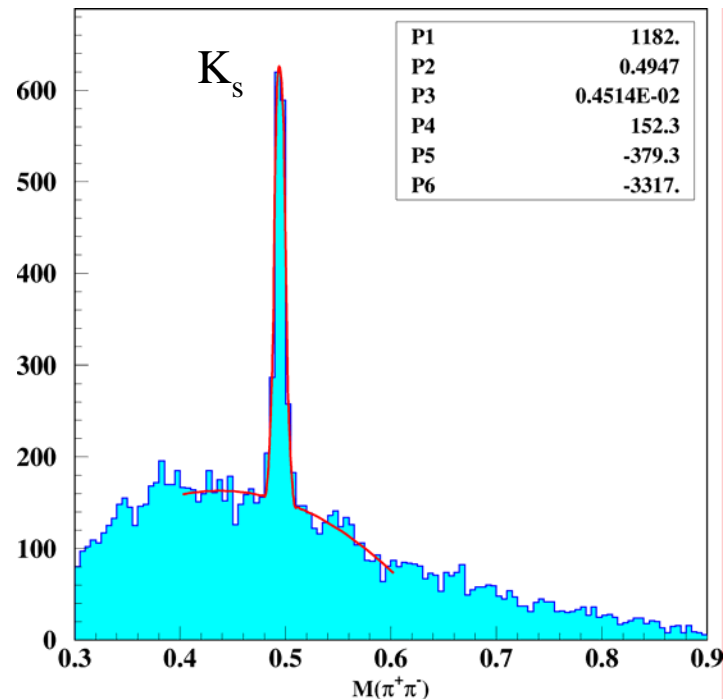
$$\gamma p \rightarrow K_s K^+(n); K_s K_s p; K^+ K^- p; K^+ K^- \pi^+(n)$$

$$\gamma p \rightarrow \pi^+ \pi^-(p)$$

(calibration reaction)



$$\gamma p \rightarrow \pi^+ \pi^- K^+ (n)$$



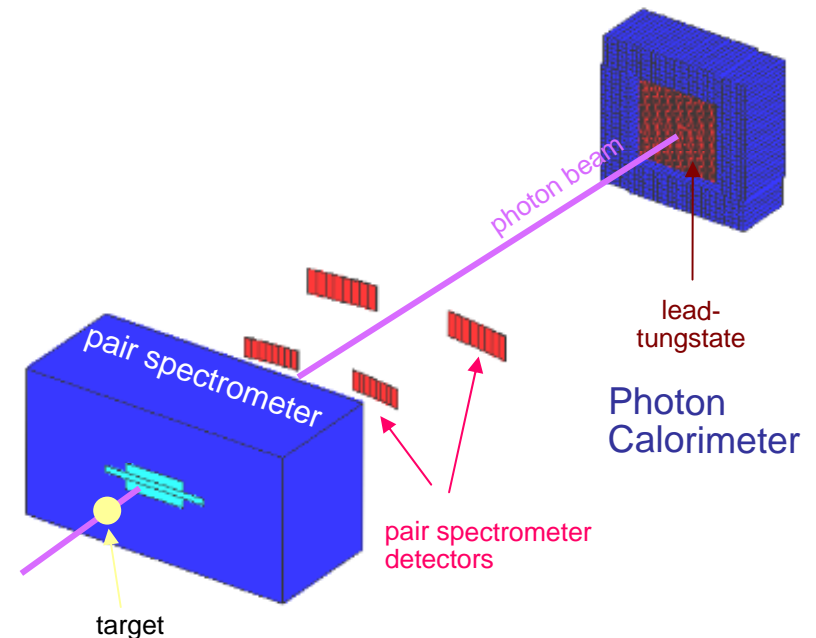
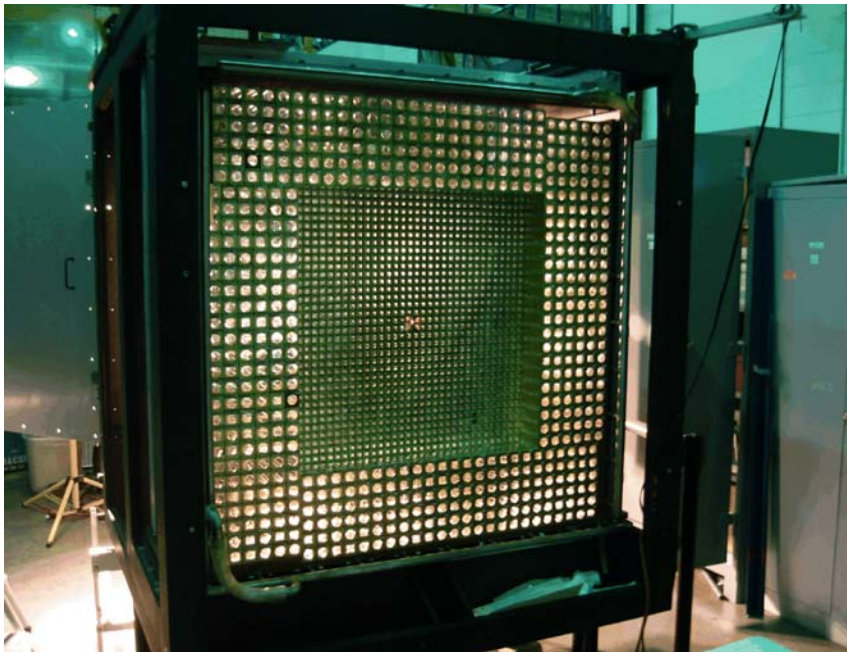
PrimEx Experiment

Purpose: Precise measurement of the π^0 lifetime using the Primakoff process.
Absolute cross section measurement.

Hybrid Calorimeter (HyCal)

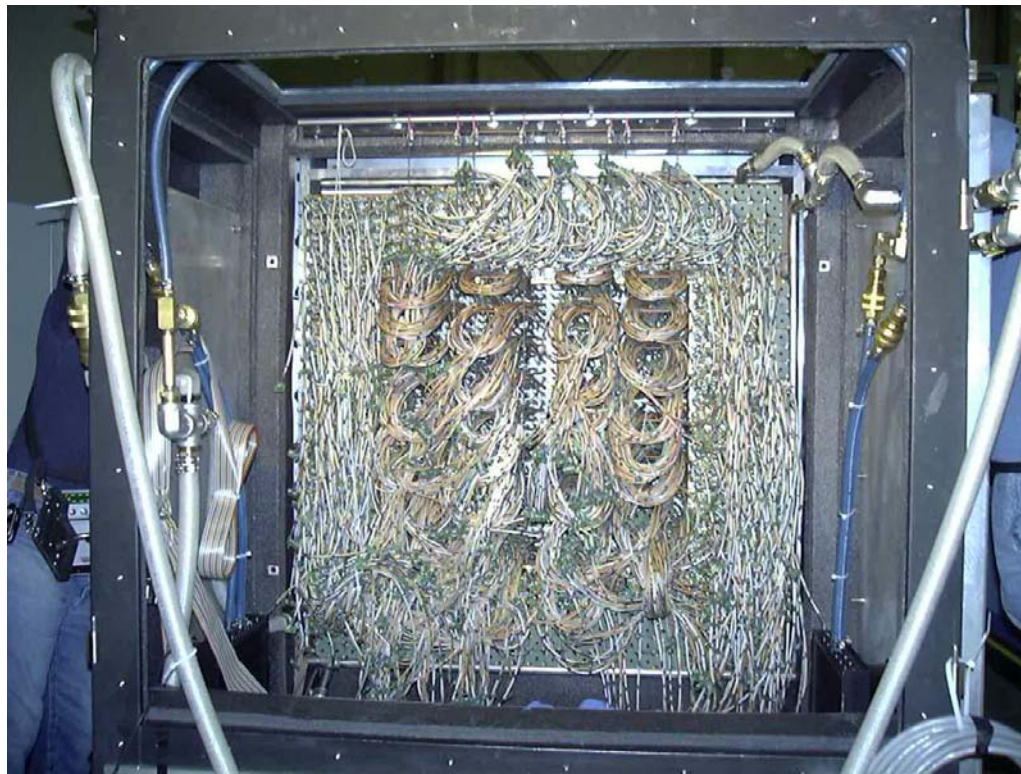
Needed to reconstruct $\pi^0 \rightarrow \gamma\gamma$ events

- Next experiment to run in Hall B



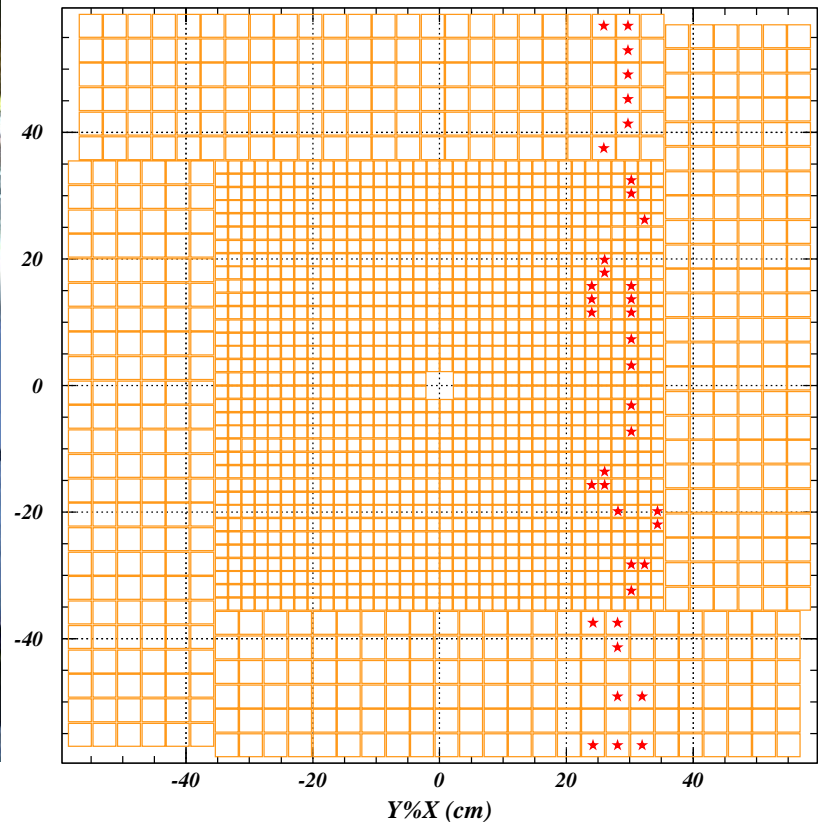
PrimEx Experiment, cont'd

View from the back



Cosmic ray event

2004/05/13 22.22



CLAS - BoNuS Experiment

Construction of curved prototype Radial Time Projection Chamber (pRTPC) successful

- GEM foil planes built using 3M Corp. GEM foils with improved gain (>100)
- New curved anode plane with pad readout (pad size $4 \times 5 \text{ mm}^2$)

Test with slow $\sim 100 \text{ MeV}/c$ protons at TUNL at the end of April successful

Testing ongoing at Jlab with γ -source and cosmic rays

- Gas mixture studies Ar/CO_2 and He/DME
- Gain stability under varying conditions (gas mixture, particle intensity, ...)

Design of GEM foils (and overall RTPC) finalized

Readout electronics expected from CERN (ALICE TPC FEE) in summer

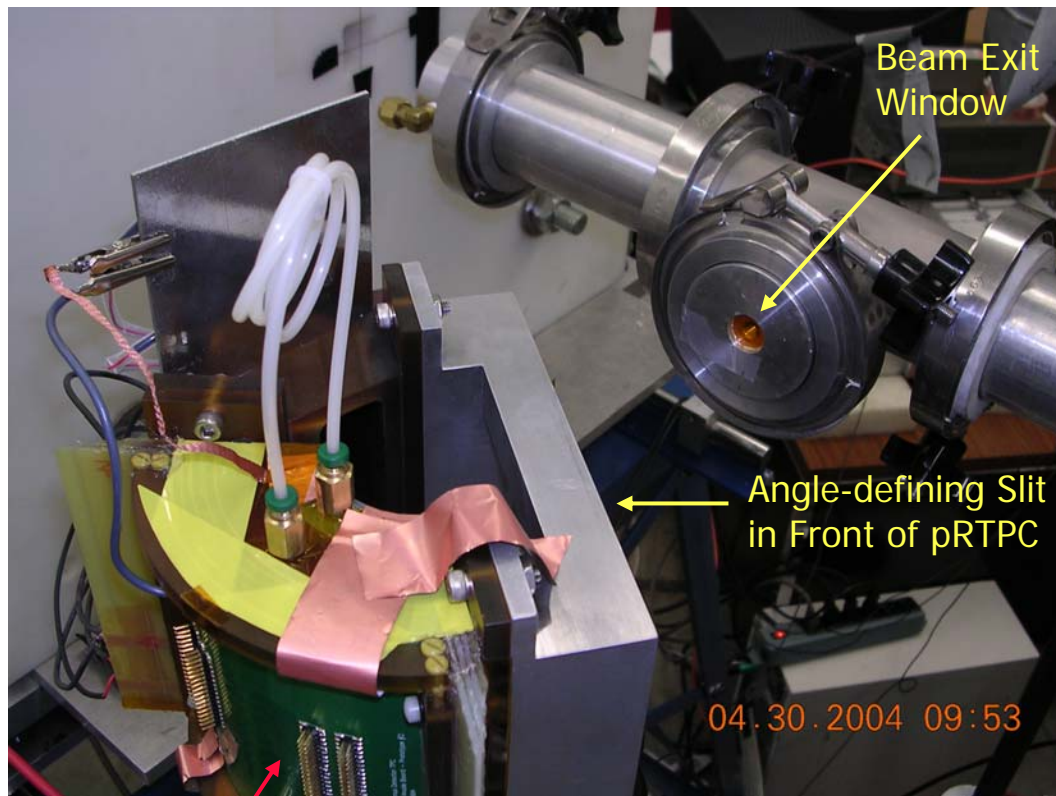
- Using presently prototype readout board, featuring CERN Alto chip set, as DAQ
- Use signal inverter/amplifier developed at Jlab (J. Profitt)

Plan for possible test run of pRTPC inside Møller magnet in conjunction with DVCS experiment in early 2005



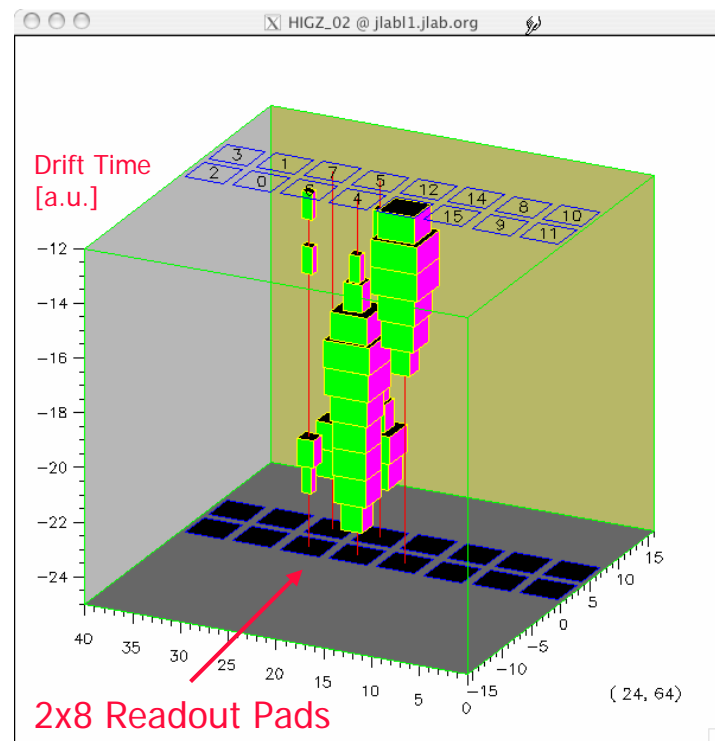
BoNuS – 2nd Test Run at TUNL

pRTPC in the TUNL “secondary proton beam line”



pRTPC Pad Readout
Plane with Connectors

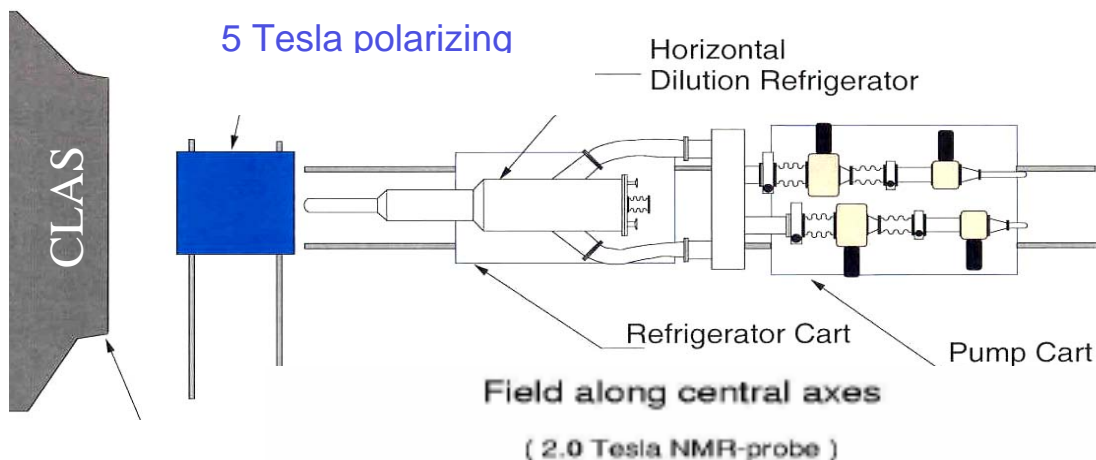
- Proton traversing pRTPC at fixed angle
- Energy deposit on three pads



Frozen Spin Target for CLAS

Technical problem:

- build polarized target for tagged photon beam
- minimum obstruction of CLAS solid angle
- low distortion of particle trajectories in magnetic field

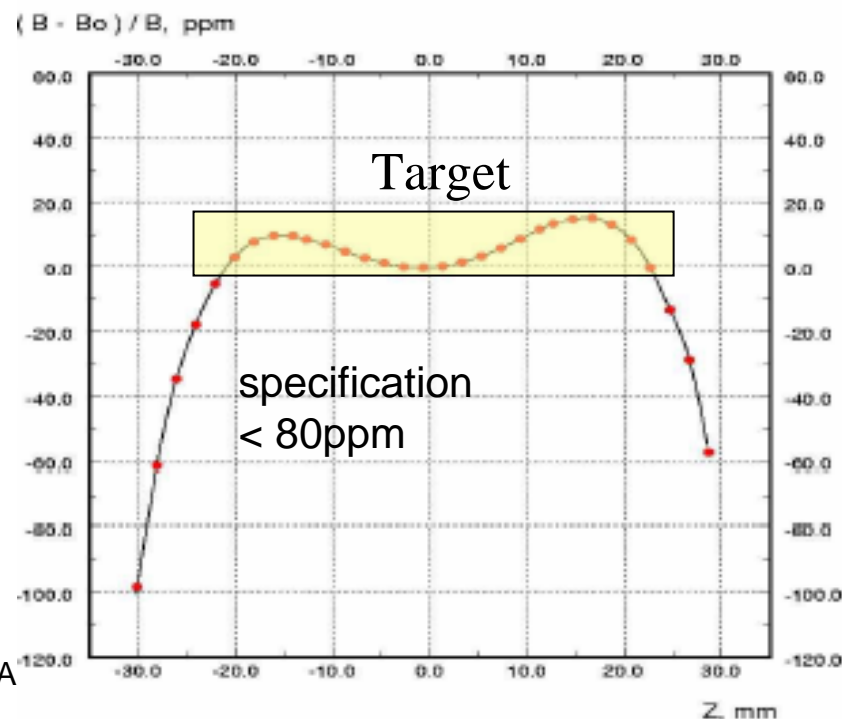


Solution:

- frozen spin target
- temperature 50mK
- magnetic field 5kG

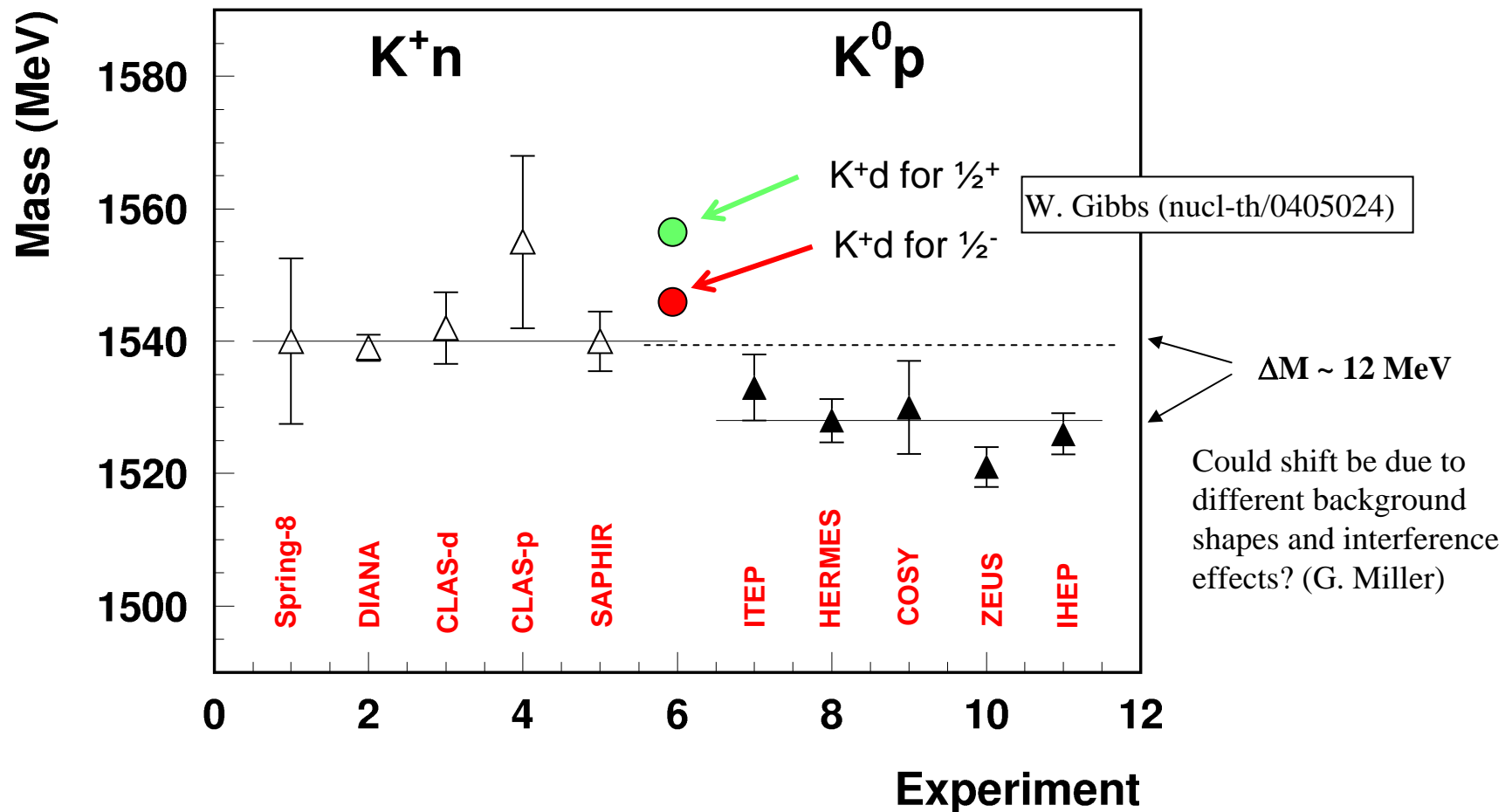
Status:

- polarizing magnet delivered, energized to full field, field distribution measured
- Holding coil prototype built
- refrigerator under construction



Energy Calibration of CLAS and Tagger

$\Theta^+(1540)$ Mass

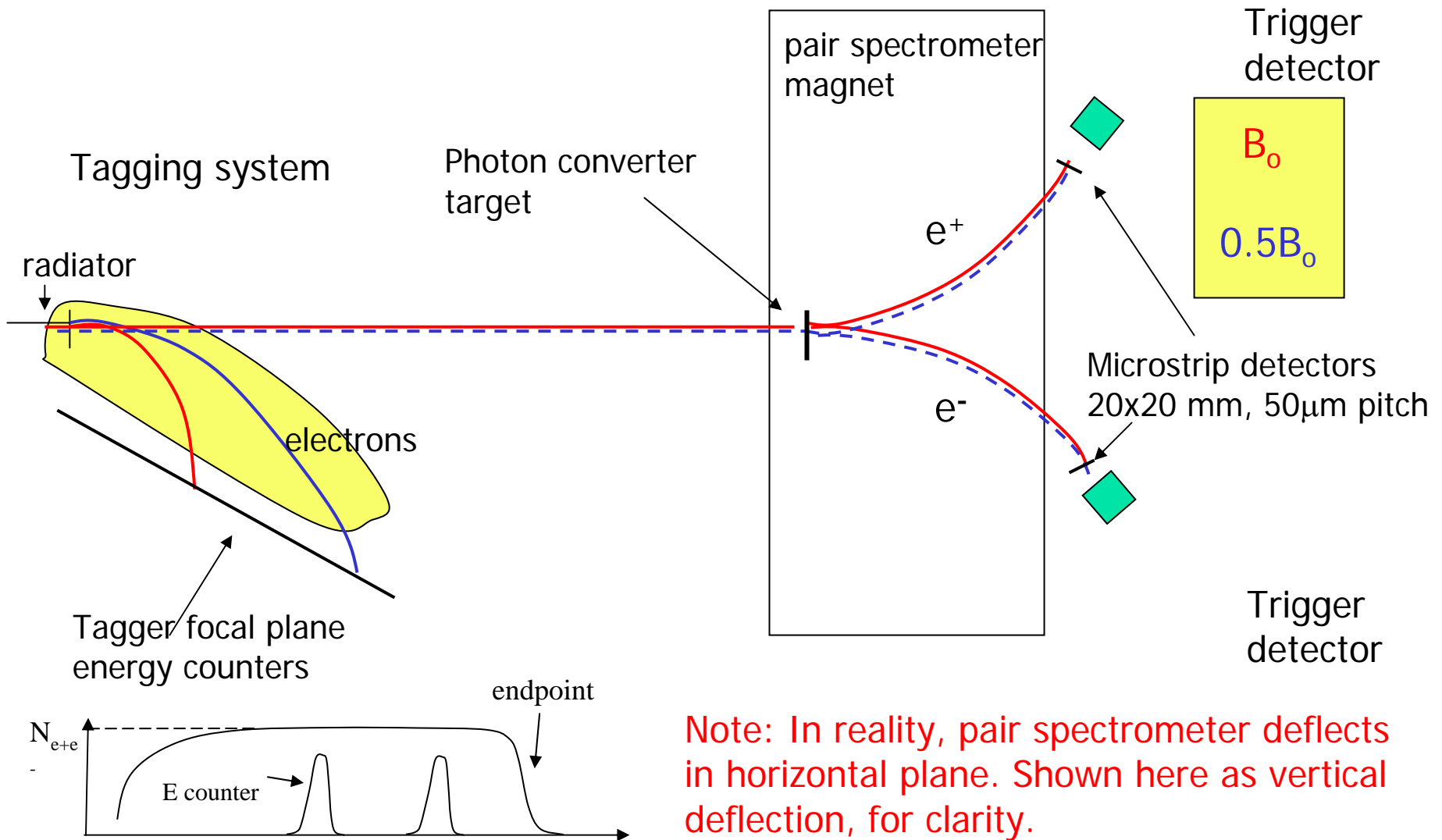


Energy Calibration of CLAS and Tagger

- Calibration problems apparent in recent Θ^+ publications using missing mass (1542 MeV vs. 1555 MeV)
- Experiments using invariant mass method (Hermes, Zeus, COSY,..) have mass near 1525-1530 MeV.
- Masses determined using missing mass techniques need knowledge of photon energy.
- Need to understand energy calibration of tagging system and CLAS momentum reconstruction in full kinematics.
 - Direct measurements using PrimEx pair spectrometer (G10/PrimEx)
 - 4C fits in fully exclusive reactions (e.g. $\gamma p \rightarrow p\pi^+\pi^-$) (M. Williams, D. Applegate, C. Meyer, CLAS note 2004-017)
 - CUA analysis (CLAS note) \Rightarrow Hall Crannell talk



Tagger energy calibration

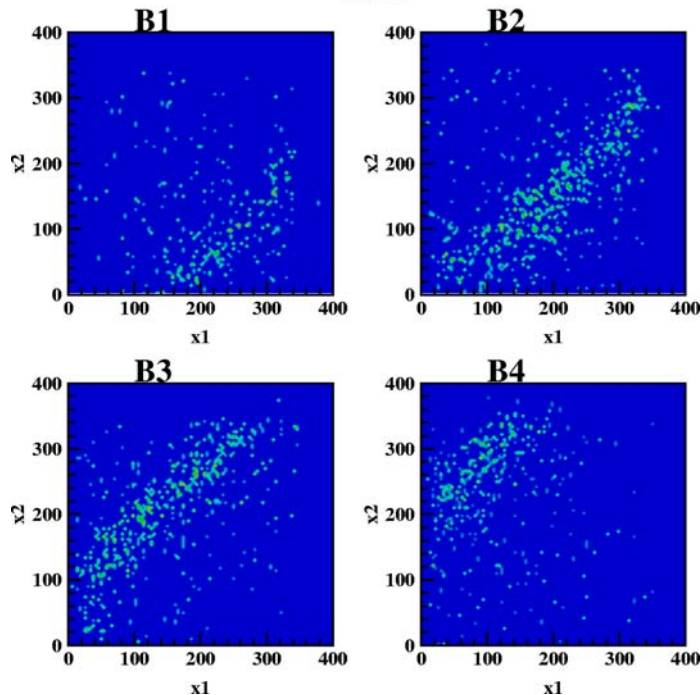


Photon Tagger Energy Calibration

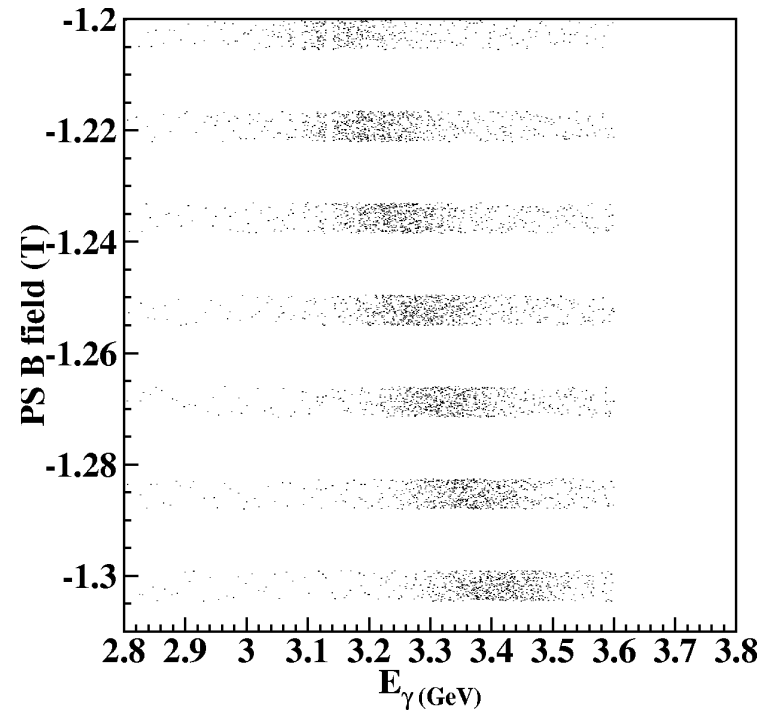
(“online” plots)

Position x_2 vs x_1 in microstrip

EID=76



B-Field vs tagger energy



Hall B Run Plan

Run group	Run time	PAC rating	Target	Energy (GeV)	Electron polar.	Comment
g11	25	A	H2	4	No	Running
PrimEx	22	A	nuclear	>5	No	HyCal
eg3-cascade	20	A	D2	>5.7	No	DAQ upgrade

unscheduled(alphabethic order)						
E7 (coherent ρ)	50	A-	D2	6.0	High	uses DVCS solenoid
E1-DVCS	60	A	H2	6.0	High	Solenoid, PbWO4 EC
G12	35	A	H2	5.7+	No	New Start Counter
EG1(g) (jeopardy)	22	A-	p	1.6-4.0	High	Frozen spin target
EG2b	11	B+	nuclear	> 5	No	
G8b	29	A-	H ₂	4.2-4.5	No	Photon polarimeter
GDH (Low Q ²)	20	A	p	1.2-4.0	High	New Cerenkov
Missing N*	38	A-	p		No	Frozen spin target
Neutron S.F.	25	A-	D ₂ gas	4-6	No	Radial TPC
Σ unscheduled	290					

Hall B 2004-2006 Schedule - Draft

05/21 - 07/19/04	g11	4.0 GeV
07/19 - 07/25/04	calibration	2 /4 /5 GeV
07/29 – 09/13/04	PRIMEX Installation, DC repairs, CC PMT replacements	
09/22 - 10/01/04	PRIMEX Engineering run	5.75 GeV
10/01 - 11/24/04	PRIMEX Physics run	5.75 GeV
12/02 - 12/23/04	eg3-pentaquark	5.75 GeV

unscheduled (schedule difficult due to energy mismatches with Hall A&C)		
01/07 - 01/30/05	eg3	5.75 GeV
01/31 - 03/03/05	E1-DVCS installation	
03/04 – 05/08/05	E1-DVCS (~30 days, 1 st installment)	5.75 GeV
	G8 (29 days)	4 - 4.5 GeV
	E1-DVCS (~30 days, 2 nd installment)	5.75 GeV
	Low Q2 GDH SR (20 days)	1–5.0 GeV
	BoNuS (25 days)	5.75 GeV
	G12 (35 days)	5.75 GeV
	Frozen spin progr. (38 days)	range



12 GeV Upgrade

Lab Management has set a timeline for CD1 approval of **one year**.

=> Need to prepare **full JLab-CDR** and be ready for review of science and equipment

- Establish editorial board in ~ two weeks
- New working groups for new physics not included in pCDR
- Broad plan for equipment “sign-on”
- Solicit NSF and Foreign contributions.
- Comprehensive NSF proposal a la “US ATLAS”
- PAC27 for CDR review only?
- New proposal vs. run out of existing approved backlog?



What does this mean for Hall B and CLAS++?

- Need to establish Hall B Upgrade working groups
 - ❑ WGs for physics in Hall B => Latifa's talk
 - ❑ WGs for equipment in Hall B => Will's talk
- We need information on what equipment users can take on
 - need this by end of this month!

What can US users do to help the process?

- Start conversations with University President about Jlab@12GeV
- Solicit Jlab letters in support of joint appointments or replacement of faculty positions.
- Invite Jlab management for talks at universities extolling bright future of NP @ 12GeV

International collaborators.

- Define your interest
- What piece of equipment could your group take on?
- Begin talk with funding agencies.



Conclusions

- Hall B has exciting physics program underway in many different areas of hadronic physics that is now coming to full fruition.
- CLAS is demonstrating discovery potential in nuclear/hadron physics
- We must preserve and further develop our capabilities for first class experiments.
- Let us put all the safeguards in to ensure our results are unassailable in the highly sensitive area of exotic states
- We need to begin work on the next phase of the 12 GeV upgrade to ensure a bright future of the exciting program in Hall B.